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Water Resources Overlays Users Guide

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Reston, Virginia

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13. ABSTRACT (Maximum 200 words)

The purpose of this guide is to assist the intelligence, engineer, logistics, terrain analyst and command functions responsible for locating, developing, storing, treating and distributing water. The guide is designed to assist in the interpretation and use of these map-linked overlays. It describes and defines the data and information on the overlays, how tney can help determine the location and availability of water, and when used with information in the base map, plan for water storage and distribution. The guide covers the content of each overlay and such topics as reliability, limitations, definitions of terms, security classification, and acquisition procedures. These overlays are used for comprehensive contingency planning, immediate water acquisition in the field, and for planning and developing additional water supplies by means including well drilling.

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I. INTRODUCTION AND PURPOSE

Commanders must be aware of the location, quantity, and quality of existing and potential water resources available for their requirements, particularly in arid areas such as Africa and Southwest Asia.

The U.S. Army Engineer Topographic Laboratories, Terrain Analysis Center (TAC), Fort Belvoir, Virginia, is tasked by the Department of Defense (DOD) to provide such information. The foundation of the information system is a military hydrology analytical system and Water Resources Data Base (WRDB); the principal products are sets of three transparent overlays keyed to 1:250,000-scale Defense Mapping Agency (DMA) topographic maps. The overlays present information available for EXISTING WATER SUPPLY FACILITIES, SURFACE-WATER RESOURCES, AND GROUND-WATER RESOURCES.

These three overlays are part of DOD's comprehensive Planning Terrain Analysis Data Base (PTADB) which addresses six additional topics; surface configuration (slope), transportation, vegetation, surface drainage, obstacles, and surface materials (refer to DMA Catalog of Maps, Charts, and Related Products; Part 3 - Topographic Products, Volume V). This guide only addresses the three water-resources overlays indentified in the above paragraph; the latest published overlays are dated 1988. When the post-1988 overlays are produced and distributed, TAC will provide guidance regarding changes, additions, and deletions.

The purpose of this guide is to assist the intelligence, engineer, logistics, terrain analysis and command functions responsible for locating, developing, storing, treating, and distributing water.

The guide is designed to assist in the interpretation and use of these map-linked overlays. It describes and defines the data and information on the overlays, how they can help determine the location and availability of water, and when used with information in the base map, plan for water storage and distribution. The guide covers the content of each overlay and such topics as reliability, limitations, definitions of terms, security classification, and acquisition procedures.

These overlays are used for comprehensive contingency planning, immediate water acquisition in the field, and for planning and developing additional water supplies by means including well drilling. Use of the ground-water overlay (along with additional source documents) for selecting locations for drilling wells may require specialized training in geology and hydrology, whereas using overlays for locating existing surface water and water facilities requires less technical training and skills. The guide is intended to assist both user types. Section VI, Ground-Water Resources, is directed towards those primarily responsible for selecting locations for drilling wells. The other sections are pertinent to and should be reviewed by personnel responsible for planning and logistical aspects such as storage, treatment and distribution.

Section II describes the content of the three topical overlays, contains an annotated illustration of a typical sheet layout, provides general guidance on interpretation including reliability and limitations, and includes directions for overlay acquisition.

Section III is a "quick-use guide" for overlays. It is designed to be an aid to those who need to be able to quickly utilize the information on the overlays. It should be used in conjunction with sections IV, V, and VI.

Sections IV, V and VI contain detailed descriptions of the three overlays including definitions of each feature, descriptions of the information in the tables, the criteria for selecting and mapping features, and guidance on how to use the overlays.

Appendix A contains a replica of each overlay legend, table, and water feature symbol currently used including additions and changes which have been made since the initial overlays were issued.

Appendix B contains an English/metric conversion guide for the metric units used in the overlays.

The following DOD publications relevant to water resources overlays, water development, treatment, storage and distribution are sources of additional information:

JCS PUB 4-01: Joint Logistics Policy and Guidance
FM 5-166: Well drilling operations
FM 5-33: Terrain Analysis
FM 10-52: Field Water Supply
TB MED 577: Occupational and Environmental Health, Sanitary Control and Surveillance of Field Water Supplies

II. WATER-RESOURCES OVERLAYS

1. DESCRIPTION

The overlays are updated and expanded supplements to standard DMA 1:250,000-scale Joint Operations Graphic (JOG) topographic maps. There have been changes in definitions and feature symbols since the initial production of overlays in 1981. Careful checking of the overlay legends and tables is suggested when working in an area requiring use of several overlays, particularly when they have different production dates.

The three overlays addressed herein contain ONLY water-resources information. They are printed on a transparent film-base material that can be stored ONLY flat or rolled. The overlays are used with the corresponding map sheet by overlaying them on the map, either individually or in a combination of topics. The overlays can be of limited use without the related maps; a substantial amount of data and information is presented, particularly outside the neatline, such as coordinates of point features; and where available, streamflow or well yield values, storage facility capacities, operational status and water quality.

2. CONTENT

For each 1:250,000-scale topographic map for which overlays are prepared, the set of three topics are usually provided. The titles and a general description of the topics are:

EXISTING WATER-SUPPLY FACILITIES-- Depicts the location of desalination and purification facilities, water tanks and towers, small reservoirs (water bodies less than 0.25 square kilometer or 0.1 square mile), cisterns, pumping facilities, pipelines, and miscellaneous facilities (such as ice plants, soda or water bottling plants); and quantity and quality of water.

SURFACE-WATER RESOURCES-- Depicts the location of streams (includes rivers), canals, water bodies larger than 0.25 square kilometer or 0.1 square mile, dams, and accessible reaches (via all-weather roads) of streams, canals, and water bodies; quantity of flow and the volume of water bodies; quality of water; and supplemental information summarizing the location and quality of the best potential sources.

GROUND-WATER RESOURCES-- Depicts the location, and the quantity and quality of water obtainable from wells, well fields, springs and qanats; ground-water potential and characteristics; and supplemental information (hydrologic and geologic) oriented towards aiding in the location of sites suitable for developing additional supplies.

3. FORMAT

The three overlays are produced in a standard format. The following figure illustrates a typical product, and each entry is described below the figure. Mapped features for which there is additional information, beyond that which can appear within the neatline, are numerically referenced to an entry in a marginal table.

3.1. OVERLAY FORMAT

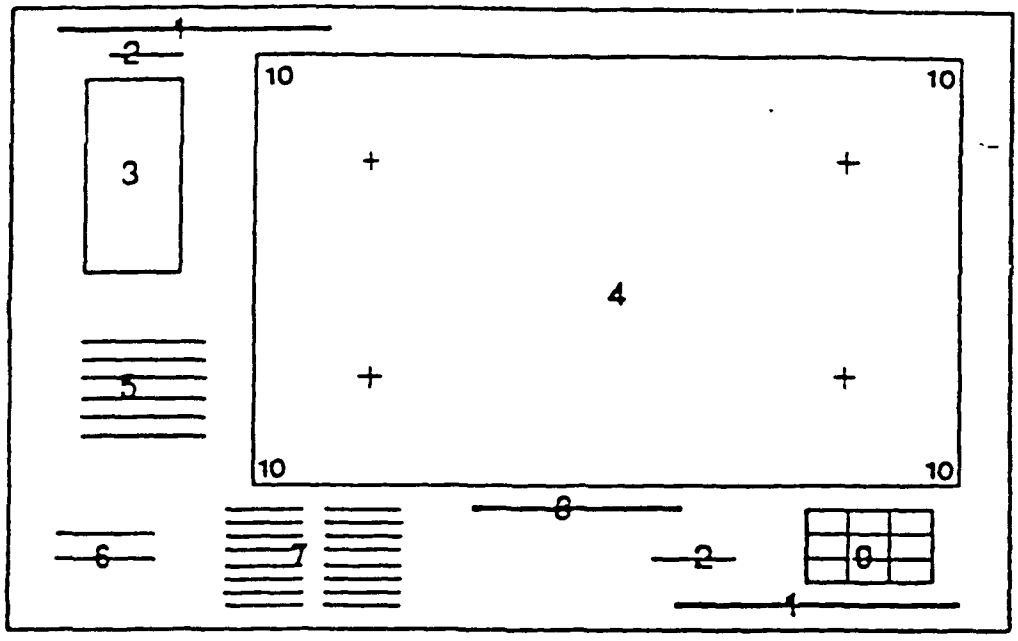


Figure 1.--Format of typical overlay.

1. Map-sheet number and topic
2. Security classification
3. Legend
4. Mapped features inside neatline
5. Overlay Characteristics Table and Supplemental Information
6. Base map name, edition, series, overlay publication date
7 Feature attribute tables, quantity and quality definitions
8. Scale bar
9. Map-sheet reference index
10. Latitude and Longitude values (additionally, four tic marks are located within the neatline to assist registration to the base map).

3.2. LEGENDS, TABLES, and SUPPLEMENTARY INFORMATION

The following tables and information are presented in the margins of the overlays. Appendix A presents format, explains symbology, and gives examples of each of the following:

3.2.1. LEGENDS

The legend provides a key to the identification of features and facilities shown on the overlay (pages 23, 24 and 25). *The symbols on a topical overlay may vary depending on when it was published. It is important to refer to the legend on each overlay. Legends for adjacent overlays may not use the same set of symbols.*

3.2.2. TABLES

(1) The Existing Supply-Facilities Data Table (page 26) is on the EXISTING WATER SUPPLY FACILITIES overlay; it provides detailed information on specific numbered facilities. Available information is provided on location, type, and capacity of these facilities, as well as other miscellaneous information.

(2) The Potential Water-Sources Data Table (page 27) on the GROUND-WATER

RESOURCES overlay can provide information on the yield and quality of water from numbered ground-water features. Information, if available, on static water level depth to static-water level, depth to aquifer, overburden and aquifer material, water use, and other miscellaneous information may also be shown.

(3) The Ground-Water Potential and Characteristics Table (page 28) provides a key to the potential, with consideration of military well-drilling capabilities, for development of ground water. The entire overlay is coded to indicate potentially G (Good), M (Marginal), P (Poor), or U (Unsuited) areas. On some overlays a potential may be further subdivided, i.e. G1, G2. This table is to be used in conjunction with the Definition of Characteristics Table (page 29) which defines the characteristics for each ground-water potential.

(4) The Definition of Characteristics Table provides classification criteria for each of the well characteristics and when used in conjunction with the Ground-Water Potential and Characteristics Table, detailed information on ground-water potential can be obtained for each area.

(5) The Water-Quality Class Definitions Table (page 30) presents the criteria for water-quality classifications used on the overlays. The table is common to all overlays, but on the SURFACE-WATER RESOURCES overlay is sometimes called the Qualitative Terms Table.

(6) The Quantitative/Stage Terms Table (page 30) is on the SURFACE-WATER RESOURCES overlay; it presents a key to the codes used to denote the amount of water to be expected in stream and canal reaches.

(7) An Abbreviations Table (page 31) is usually included on all overlays; it provides a reference to units and other abbreviations used on the overlay.

(8) A Conversions Table (page 31) is usually included on all overlays; it provides equations for converting metric units used on the overlays to English units.

3.2.3. *SUPPLEMENTARY INFORMATION STATEMENTS*

A Streams-Characteristics Statement (page 32) is included on all SURFACE-WATER RESOURCES overlays; it contains information on the availability of surface-water resources; a brief overview of the flow characteristics of the rivers and streams; and generally an indication of which are the best water sources and where the best accessibility is. It also presents information on the rainfall distribution (wet and dry seasons), and may also contain specific information related to the tables or text in the overlay margin or to information displayed on the overlay itself.

A Supplemental-Information statement (page 33) is included on the GROUND-WATER RESOURCES overlays. This is an overview of the ground-water conditions, and may contain specific information related to one or more of the tables, or information displayed within the overlay itself.

4. INTERPRETING THE OVERLAYS

Information on the overlays varies widely in terms of detail and currency, and reflects analysts' interpretations of the best data available at the time of preparation. Overlays and the JOGs are year-dated and the dates and/or editions may not be the same. Many questions can be answered using the information contained on the overlays. For example, the following six questions can often be answered by using the overlays and accompanying map.

(1) What is a likely source of water?
(2) Where is the water source located?
(3) Where are all-weather access points to the water?
(4) How much water is available?
(5) What is the quality of the water? Is it Fresh, Brackish or Saline?
(6) When is the water available?

Phrased another way, the question might be "Will the water supply in this area support "X" number of troops and associated equipment for "Y" number of days?".

In addition to serving as a supplement to the information on the base map, the overlays should be considered supplements to each other. This is because of the close relationship between the sources of water. Similarly, they should be used in conjunction with the other PTADB overlays to assist in determining additional accessibility to water sources.

Prior to analyzing an individual overlay, the three water-resources topics should be reviewed to become aware of the full range of water-resources information presented for the area of interest. If this area is close to the margins of a map, review of the adjacent map(s) and overlay(s) is essential prior to drawing conclusions and preparing plans. Among the source materials available for some countries is the Army Country Profile (ACP), formerly the Army Intelligence Survey (AIS); this document normally contains large area overviews of the geology, hydrology and related water-resources information, and often includes valuable site-specific information. Reference to this document at the start of an evaluation is suggested.

5. RELIABILITY AND LIMITATIONS

All the data and information used by analysts when preparing overlays are NOT of the same quality, age, or reliability. When preparing overlays, analysts carefully consider hydrologic relationships in order to maintain consistency between information on the three overlays. The primary objective is to provide reliable data on the location, quantity and quality of water resources for military operations. Although features on the overlays are plotted as accurately as possible based on the information provided, dislocations of as much as one kilometer may occur. Occasionally, due to the almost complete lack of information an overlay may contain notes such as "Southwest portion not fully evaluated", or "Overlay not fully evaluated".

Caution should be taken not to over estimate the resources, or to under estimate the indigenous population's domestic water requirements. It is critical to constantly be aware, particularly in arid areas that water is a limited commodity and that where water is lacking is often more important than where it is present. Thus, not all reported water supplies should be assumed to be fully available for military use. Some constraints and limitations to be considered when evaluating water supplies depicted on the overlay include the possibility that some features may have been removed or destroyed, are no longer in working order, or have been abandoned; known limitations/constraints are noted in the tables on the overlays. Some examples are:

(1) a well has run dry due to natural or man-induced causes, the pump is broken, or the power supply has been terminated;

(2) a pipeline flow ceased because the flow was directed to another line;

(3) a dam-gate opening resulted in a low-water level and the supply is farther from the access point than the retrieval capability of the pump/hose;

(4) a well reported as producing 75 liters per minute (Lpm) (20 gallons per minute) has done so for many years, but is only capable of doing so for 8 hours per day (not known to the analyst); pumping at this rate for 24 continuous hours may result in a dry hole for an extended period or in permanent destruction of the pump or well;

(5) a facility may exist and be operational but not reported on the overlay because its presence was unknown or it may be newer than the overlay.

Examples of constraints that need to be considered when preparing water requirements analyses include:

(1) all or most of the available supply from a source may be consumed by indigenous population;

(2) output from a waste-treatment plant could be a suitable input to a reverse osmosis or another type of treatment facility; caution is required because chlorine in the waste treatment process can destroy a reverse osmosis system filter;

(3) a large capacity water tank or tower may be partially or totally empty;

(4) water in a stream segment may have been diverted by construction of a dam, a canal, or was withdrawn for other uses since the overlay was produced.

Examples of constraints in the interpretation of water-quality information include:

(1) over-pumping (too long or too fast) a fresh-water well in a coastal area could result in retrieving brackish water needing further treatment;

(2) higher or lower than normal stream flow, whether by natural or man-made causes, could result in higher concentrations of contaminants (reduced quality) and increased turbidity which could clog many water-purification systems.

(3) deliberate or accidental contamination may have occurred.

(4) pollution or contamination may have occurred as a result of increased or changed water uses.

6. EXISTING AREAS OF COVERAGE

By the end of 1990, approximately 615 sets of overlays have been produced for sections of Africa and Southwest Asia. Portions of Europe and additional areas of Africa and Southwest Asia are in production and/or planned for the near future.

7. SECURITY CLASSIFICATION

With few exceptions, all overlays are classified either CONFIDENTIAL or SECRET. There are a few UNCLASSIFIED overlays, and none are classified higher than SECRET. Some overlays have additional caveats such as NOFORN or WNINTEL.

8. HOW TO ORDER

Overlays can be obtained from DMA, and are listed in their "Catalog of Maps, Charts, and Related Products; Part 3 - Topographic Products, Volume V, Section 3 (dated July, 1987) - Planning Terrain Analysis Data Base (PTADB) Standard/Non-Standard (1:250,000) Thematic Overlays". Each overlay is identified by a 14-character Stock Number: this number has four sub-parts;

1. Series Number of the relevant topographic map; five character map Series Number excludes the fifth character -- 1501S becomes 1501.

2. Letter "D" denotes non-lithographic product series.

3. Sheet Number of relevant topographic map -- NG42-10 becomes NG4210; and NG42-6 becomes NG4206.

4. Identification code for specific terrain factor overlays:

T35 Water Resources (Existing Water-Supply Facilities)
T36 Water Resources (Ground-Water Potential and Characteristics)
T37 Water Resources (Surface-Water Resources)

To order only the Ground-Water Resources overlay for topographic map sheet Series 1501S, Map Number NG42-10, request 1501DNG4210T36.

III. QUICK-USE GUIDE FOR WATER-RESOURCES OVERLAYS

The purpose of this section is to provide a brief description and orientation to the use of the overlays. It is primarily directed to those not having used the overlays previously and having an immediate need for information on location, quantity, or quality of water. It also can serve as an overview to the detailed discussions in subsequent sections.

1. Define area of interest.

2. Obtain 1:250,000-topographic maps (JOGs) and WATER-RESOURCES OVERLAYS for the area. There are usually three overlays for each JOG:

   EXISTING WATER-SUPPLY FACILITIES
   SURFACE-WATER RESOURCES
   GROUND-WATER RESOURCES

3. Find the area of interest on the map(s).

4. Overlay the JOG sheet with each of the water-resources overlays, beginning with the EXISTING WATER-SUPPLY FACILITIES overlay, followed by the SURFACE-WATER RESOURCES overlay, and finally by the GROUND-WATER RESOURCES overlay. Existing water-supply facilities and surface-water sources are the most direct sources of water; these should be examined first. In desert areas there may be very limited or no surface water, and in sparsely developed areas there may not be any existing water-supply facilities. In these situations, other than trucking or piping the water, ground water may be the only source of water.

   4.1. Place the EXISTING WATER-SUPPLY FACILITIES overlay over the JOG, and then use the overlay to locate facilities that may be sources of water. The legend is used as a key to the identification of the types of facilities.

   Purification and Desalination Plants
   Water Pipelines and Pumping Facilities
   Water-storage Tanks and Towers
   Small Reservoirs and Cisterns
   Miscellaneous sources

   These facilities can often be direct sources of water, and pipelines and pumping facilities can be used to transport water from storage facilities or from surface-water or ground-water sources. For some facilities only the type of facility and its location is known, but for numbered facilities additional information is in the Existing Supply-Facilities Data Table in the overlay margin. This table includes available information on location, type, and capacity of plants, pipelines, storage tanks, cisterns, and small reservoirs. The table may also contain information such as the type of desalination plant, whether the facility is operated by military or civilian authorities, what the water is used for, or if the water is fresh, brackish, or saline.

   (See Section IV (page 11), EXISTING WATER-SUPPLY FACILITIES, for more information on how to use and interpret this overlay.)

   4.2. Overlay the JOG sheet with the SURFACE-WATER RESOURCES overlay to locate surface-water features. The legend is used as a key to the identification of the types of features:

   Streams
   Canals
   Water bodies
   Dams
   Accessibility (to water)

   These features can be valuable sources of water if they contain enough water for anticipated requirements. The marginal tables must be used to determine the quantity and quality of water. Each stream or canal reach is identified with a code. that provides information on:

water quantity and stream stage: The amount of water to be expected in a stream reach at a certain stream stage. (i.e. Lm indicates a Large amount of water at a mean stage).

water quality: stream reaches are shown to be fresh, brackish, or saline (F, B, or S, or FW, BW, or SW) for all perennial streams and for some intermittent streams.

permanence: streams are shown to be perennial (solid line) or intermittent (dashed line). Perennial streams are permanent; they flow all year long. Intermittent streams flow only during part of the year, often only in response to rainfall or snowmelt; much of the year they may be dry.

accessibility: a heavy solid line adjacent to a stream, canal, or water body indicates that section is accessible to vehicles and is within 100 meters (328 feet) horizontal and 10 meters (33 feet) vertical of an all-weather road.

See Appendix A for detailed help on the interpretation of these codes.

The Stream-Characteristics Statement contains general and specific information on the location of the best fresh-water sources, water quality, and when to expect high water or low water. Information may also be available on the accessibility of the stream reach (best and/or problem areas), and on annual precipitation and seasonal distribution.

(See Section V (page 14), SURFACE-WATER RESOURCES for more information on the use and interpretation of this overlay.)

4.3. Place the GROUND-WATER RESOURCES overlay over the JOG to locate ground-water features. The legend is used as a key to the identification of the features:

Wells	Qanats
Well fields	Areas of ground water potential
Springs	

Wells, springs, or qanats may not be as easy to tap as existing water-supply facilities or surface-water features, but they may be able to provide adequate water.

The Potential Water-Sources Data Table will provide specific information for numbered features. This table can provide information on the yield and quality of wells, well fields, springs, and sometimes qanats. To the extent available, information on depth-to-water, overburden and aquifer material, water use, and miscellaneous sources may also be shown.

Many of the features may not be numbered which indicates no additional information is available. To determine the potential of these features or the potential of drilling a new well, requires an understanding of the ground-water potential of the area of interest.

The entire overlay contains coded information that describes the potential for drilling a well. These codes define the four basic categories of ground-water potential: Good, Marginal, Poor, or Unsuited. Use these codes with the following two tables to estimate the expected yield from a well, the expected depth-to-water, an estimate of the aquifer thickness, the expected quality, and information on the materials that make up the aquifer and the overburden (the materials above the aquifer).

The Ground-Water Potential and Characteristics Table provides a key to the potential for development of ground water. The entire overlay is coded to indicate potentially G (Good), M (Marginal), P (Poor), or U (Unsuited) areas. On some overlays a potential may be further subdivided, i.e. G1, G2. This table is to be used in conjunction with the Definition of Characteristics Table which defines the values on each potential in the characteristics column.

The values shown in the Ground-Water Potential and Characteristics Table should be referenced to the Definition-of-Characteristics Table for information on the ranges

to be expected for the yield, depth-to-water, aquifer thickness, water quality, aquifer materials, and overburden materials. On a typical overlay, a 1 in the yield column of the Ground-Water Potential and Characteristics Table, when referenced to the Definition-of-Characteristics Table, indicates the expected yield is >400 Lpm (greater than 400 liters or 106 gallons per minute).

(See Appendix A for a more detailed explanation of these tables and for more information on the GROUND-WATER RESOURCES overlay see section VI, page 17.)

Use the legend on each overlay as a key to the identification of each of the features or facilities. *The symbols may vary on an overlay depending on when it was published. It is important to refer to the legend on the overlay* being used; symbols on adjacent overlays may vary (see figures 3, 4, and 5).

CAUTION! Information and location of the features and facilities shown on this overlay have been prepared using the best data available at the time of preparation, but locations may be in error by as much as one kilometer, usage may have changed, or the feature may no longer exist.

IV. EXISTING WATER-SUPPLY FACILITIES OVERLAY

1. GENERAL

The primary purpose of this overlay is to show the location, capacity and quality of water in existing production, distribution, and storage facilities, and where available, reported quantities. These facilities include desalination, waste treatment and other purification plants, storage facilities such as water tanks and towers, cisterns and small reservoirs, pumping facilities, pipelines, and miscellaneous supply facilities (such as ice making and bottling plants). The overlay displays all known man-made or improved facilities except surface-water bodies larger than 0.25 square kilometers (0.1 square miles) and canals (both of which are shown on the surface-water overlay); and wells, well fields, springs and qanats (which are shown on the ground-water overlay).

2. WATER-RESOURCES FEATURES

The following are the definitions of the features reported on the overlay.

Desalination Plant--A facility that removes dissolved salts from brackish or saline water in order to improve water quality.

Purification Plant--A facility, other than a desalination plant, that improves water quality. Sewage-treatment plants are considered purification plants.

Storage Facility--A facility that is used for storing water. It includes:

Water Tank - A large receptacle, made of masonry, metal or wood, for holding or storing water at ground or partially below ground level. May also be located on top of another structure such as a building.

Water Tower - A standpipe (large vertical pipe into which water is pumped in order to produce a desired pressure) or a tower supporting a large receptacle for storing water.

Small Reservoir - A pond, lake, basin, or other feature less than 0.25 square kilometers (0.1 square miles) in area, either natural or created in whole or in part by the building of engineering structures. These features are mapped as either perennial or intermittent; intermittent is defined as being seasonally dry.

Cistern - An artificial or a natural underground reservoir, covered and usually not visible from the surface or from overhead. These features are mapped as perennial or intermittent.

Pumping Facility--A facility that moves or lifts water from one point to another; usually collocated with another supply facility such as a pipeline or canal. Pumping facilities along major pipelines are shown separately; these include pumps to lift water from major surface-water features, or to transfer water from one facility to another. Small pumping facilities collocated with another water supply facility are not identified separately.

Pipeline--An above- or below-ground conduit including covered aqueducts for carrying water from one point to another, pumped or by gravity. Only important pipelines (flows greater than 400 liters (106 gallons) per minute are shown. Where available, diameters and flow capacities are given in the overlay Data Table. The direction of flow is indicated by arrows, and the pipeline symbol used indicates whether the pipeline is above or below ground.

Miscellaneous Source--Includes features not in the above categories but identified because they are good potential sources of water. Examples are water bottling, ice or soft drink plants, swimming pools,and fish hatcheries. The features are identified and briefly described in the overlay Data Table. Oases and settlements may be shown as miscellaneous sources on overlays that have very few existing water-supply features; they are identified by number and listed in the overlay Data Table as probable sources of unknown capacity.

3. LEGEND AND TABLES

The following tables and information are presented in the margins of the overlay. Appendix A presents format, defines symbols used, and gives examples of each of the following:

Legend
Existing Supply-Facilities Data Table
Water-Quality Class Definitions Table
Supplemental Information
Abbreviations Table
Conversions Table

4. CRITERIA FOR SELECTING AND MAPPING FEATURES

Features are located on the overlay based on the following criteria.

The symbol for a facility is centered over the mapped or determined location except when there are many facilities in a small area. In such cases, leader lines point to the location of the facility. Facilities for which detailed information such as quantity produced, pumped, stored or processed, water quality, or operational status is available are numbered, and that information and the UTM coordinates are in the overlay data table.

In areas where there are many closely located facilities only preferred facilities are shown on the overlay. The ranking from highest to lowest preference is:

Water Purification and Desalination plants
Pipelines
Pumping Facilities
Storage Tanks and Towers
Small Reservoirs
Cisterns
Miscellaneous Sources

In small areas with many facilities, often in or near large communities or massive water development/treatment complexes, facilities may not be individually plotted; their presence is defined by a dashed line annotated "area of numerous features" and the feature type is noted.

5. HOW TO USE THIS OVERLAY

This overlay, with its accompanying map, can assist in locating potential sources and or preparing plans for the acquisition and distribution of water. The overlay can be used to:

(1) locate a facility which can directly be used as a source of water, either potable or suitable for additional treatment, such as a treatment plant product, a pipeline, or a water tank/tower. Data in the Existing Supply-Facilities Data Table may provide information on the quantity and/or quality of water, the operational status of the facility, and use of the water; the latter is particularly important in cases where the water may be consumed by the local population;

(2) locate a pumping facility/pipeline junction which may be suitable for obtaining water for transfer to where needed rather than by truck or water line;

(3) locate a water tank or tower suitable for storage of water;

(4) locate potential water sources such as streams and wells by combining with the map and the SURFACE-WATER RESOURCES and GROUND-WATER RESOURCES overlays;

(5) locate water-use points and areas such as communities or large irrigated agricultural areas by combining with the map;

(6) provide information that may be useful in interpreting the GROUND-WATER RESOURCES overlay; for example, storage facilities such as tanks and towers may indicate that wells are nearby although the wells are not portrayed on the EXISTING

WATER-SUPPLY FACILITIES overlay, nor is there any other apparent source of water. *However, the tanks and towers could be provided water from an unmapped pipeline, or could be isolated facilities which store water that has been trucked in;*

(7) determine whether the facility contains Fresh, Brackish or Saline water.

(8) locate an isolated pumping facility which could indicate the existence of an unreported pipeline, well, or small reservoir.

V. SURFACE-WATER RESOURCES OVERLAY

1. GENERAL

The Surface-Water overlay supplements the map and depicts surface-water resources such as large perennial water bodies (lakes and reservoirs), streams, canals, surface-water access (areas where all-weather access to surface water meet specific criteria) and dams. It also contains information, where available, on water volume, flow rates, quality, and seasonality of water.

This overlay ONLY portrays standing water bodies having a surface area of at least 0.25 square kilometer or 0.1 square mile (whether perennial or intermittent), streams and canals (whether perennial or intermittent) with discharges of at least 40 liters per minute (slightly more than 10 gallons per minute) and dams which create a water body greater than 0.25 square kilometer or 0.1 square mile. The quality of perennial flowing or standing water is classified as either fresh, brackish or saline (see Water Quality Class Definitions Table in Appendix A). The primary focus is on perennial flowing or standing water bodies, but information is also provided for intermittent features.

Because of the complexity of displaying the information on overlays with substantial amounts of surface water and/or information, use of this overlay requires more evaluation than the other two overlays.

2. WATER-RESOURCES FEATURES

The following are the definitions of features reported on the overlay

Stream (Perennial or Intermittent)-- A flowing water body including rivers, streams and creeks.

Canal (Perennial or Intermittent)-- A constructed or artificial open, or non-enclosed channel or aqueduct for transporting water.

Perennial Stream or Canal-- Flows continuously all year long (including dry seasons) and has a minimum flow of 40 liters per minute (11 gallons per minute).

Intermittent Stream or Canal-- Flows greater than 40 liters per minute (11 gallons per minute) only part of the year.

Accessible Reach-- A section of a Perennial or Intermittent Stream, Canal or Water Body which is within 100 meters (328 feet) horizontal or 10 meters (33 feet) vertical distance from an all-weather road. Accessibility to sea water is not portrayed.

Water Stage--A way of expressing the seasonal flow of water in a stream. Water stages are reported in one of three categories:

Mean-water - The most frequently occurring stage, in practice the average.

High-water - The stage during the height of the annual wet season.

Low-water - The stage during the height of the dry season.

Note that extreme stages --flood or drought--are not defined. Also that high and low water stages are "averages" that are not usually exceeded more than once in 5 years. For intermittent streams, the mean-water stage corresponds to the most frequent water depth when the stream is flowing.

Surface-Water Body (Perennial or Intermittent)-- A body of water; pond, lake, basin or other feature, either natural or totally/partially man-made, and 0.25 square kilometers (0.1 square miles) or greater in area.

Perennial Water Body-- A body of water that exists throughout the year, including dry seasons, and is greater than 0.25 square kilometer (0.1 square mile) in area.

Intermittent Water Body-- Seasonally dry, or with a surface area LESS than 0.25 square kilometer (0.1 square mile) part of the year. Ephemeral streams (flow only in response to precipitation or snow-melt) are mapped as intermittent streams.

Dam--A man-made barrier across a water course which creates a water body greater than 0.25 square kilometer (0.1 square mile) in area.

3. LEGENDS, TABLES AND SUPPLEMENTARY INFORMATION

The surface-water overlay contains information related to the quantity, quality, size, and accessibility, and location of surface-water resources. Much of this information is contained in the legends, tables, and text presented in the margins of the overlay. Appendix A presents format, explains symbology, and gives examples of each of the following:

Legend
Water-Quality Class Definitions / Qualitative Terms Table
Quantitative/Stage Terms Table
Streams-Characteristics Statement
Abbreviations Table
Conversions Table

4. CRITERIA FOR SELECTING AND MAPPING FEATURES

The materials used to compile the overlay include geologic maps, seasonal imagery when available, the drainage network from topographic maps, and sources which provide information on water quantity and quality.

Data and information about water quantity and accessibility, not quality, are given priority in compiling the overlay. Within each group category, fresh water features are given the highest priority, followed by brackish water and saline water. In the absence of other supplies, brackish and saline water can be a valuable resource because with desalination and purification equipment most water supplies can be made potable. In areas where there are many closely spaced surface-drainage features, only preferred features are individually shown on the overlay; a closely located group of features may be enclosed by a dashed line with an interior note indicating that it is an "area of numerous" features. The ranking from highest to lowest preference is:

(1) perennial water bodies (lakes, reservoirs, streams and canals) with accessible reaches, with priority given to the largest,

(2) perennial water bodies lacking good access,

(3) intermittent lakes and streams with access,

(4) large irrigation systems supplied by water from wells,

(5) other intermittent water bodies.

Where the density of features prohibits showing lower priority categories, these categories are omitted and a note such as "Only Accessible Perennial Water Bodies Mapped" is placed in the lower margin of the overlay.

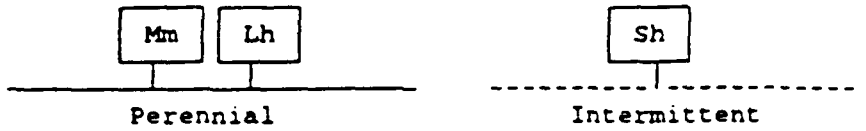
6. HOW TO USE THIS OVERLAY

To fully utilize this overlay, it is necessary to become familiar with the general characteristics of the surface water in the area; this is best accomplished by using the overlay and the accompanying map together. Examine the water features portrayed on the overlay, the overlay legend, and the tables and text. An understanding of the Quantitative/Stage Terms Table (Appendix A) and review of the Stream-Characteristics Statement is necessary prior to examining the overlay in search for water.

Every perennial stream segment (section of a stream definable by hydrologic changes

or stream junctions) is identified by at least one Quantity/Stage code, but may be identified by more than one to show quantity characteristics at different flow levels. For example, one segment may be identified as **Mm** (Moderate quantity at mean water stage,). The code **Ll** (Large quantity at low water stage,) is given priority over all other codes; for example, **Lh** (Large quantity at high water stage,) would not add information to this stream segment, since a large flow at low flow periods insures a large flow at high stage periods.

For graphic clarity when more than one Quantity/Stage code is recorded for a single segment, both sets of codes have pointers to the same point on the channel. Every Intermittent stream segment will contain a Quanity/Stage code, and a Quality code if the water quality is known. This information will appear on the overlay as follows:



perennial water bodies are outlined on the overlay; a quality code is shown and when available, the volume is shown in thousands of cubic meters. If surface-water sources are not adequate to meet requirements, additional sources may be trucked in, piped in, or supplemented by water from existing wells, springs, or by developable ground water (drilling wells); refer to Section VI, Ground-Water Resources.

Some guidelines, constraints, and limitations to bear in mind when using this overlay include:

(1) The best sources of surface water are large-volume perennial steams and surface water bodies with good access to all-weather roads.

(2) Sources of water with the least potential are intermittent streams with low-to-moderate flows.

(3) The quantity of water at any point may be seriously lowered by upstream withdrawal of water for industrial, municipal, agricultural, or military uses. Quantities may be considerably less than reported on the overlay.

(4) Water quality in both perennial and intermittent streams at the point of interest can be seriously affected by discharges of waste from upstream industries or communities.

(5) The quantity of water withdrawn by an operation, particularly at low flow periods, may seriously lower the quantity and adversely affect the quality of water to downstream users.

(6) If withdrawn water is used or contaminated, and then returned to the stream, it could adversely affect downstream users.

(7) Large streams will appear on the overlay; some small streams will not.

(8) The criteria and information for canals is the same as for streams.

VI. GROUND-WATER RESOURCES OVERLAY

1. GENERAL

The purpose of the ground-water overlay is to show the locations of existing wells, well fields, springs, and qanats, and to identify the areas that have the best potential for drilling new wells. The overlay evaluates areas based on the expected quantity and quality of water with specific consideration of military-equipment capabilities. Existing ground-water features are plotted on the overlay and for some features (the numbered features) additional information is provided in the table: Potential Water-Sources Data. The overlay is sufficiently detailed to aid in locating the general area of potential drilling sites, but generalized enough to be readily understandable by all users; the overlay is NOT a total substitute for evaluation of additional source materials such as locally obtained drillers logs, and detailed on-site investigations by technical specialists prior to selecting the specific location to drill a well.

2. WATER-RESOURCES FEATURES

The following are the definitions of features reported on the overlay.

Aquifer - a formation that is sufficiently saturated with water to yield significant quantities of water to wells or springs.

Depth-to-aquifer - used symonynously with the depth military well drillers would be required to drill in order to yield water.

Depth-to-water - vertical distance between land surface and the standing water level in a well; also known as static water level.

Overburden - silt, sand, gravel, or rock formations that overlie an aquifer.

Spring - a natural outflow of water.

Well - a pit or hole dug or drilled for the purpose of reaching a supply of water below ground level. Types of wells include pumped wells, flowing wells, and wells that are constructed for other purposes such as observation and/or monitoring of ground water levels.

Well Field - A tract of land containing a number of interconnected wells, not just an area of closely-spaced individual wells.

Qanat - A gently-sloping tunnel which taps a supply of ground water and transports it some distance by gravity to where the tunnel intersects the surface (see figure 2). This feature occurs in the Middle East and North Africa. On some foreign maps may be spelled kanata, kanat, ghanat, and ghanata; in Oman, it is cited as falaj, and in Morocco as rhettara.

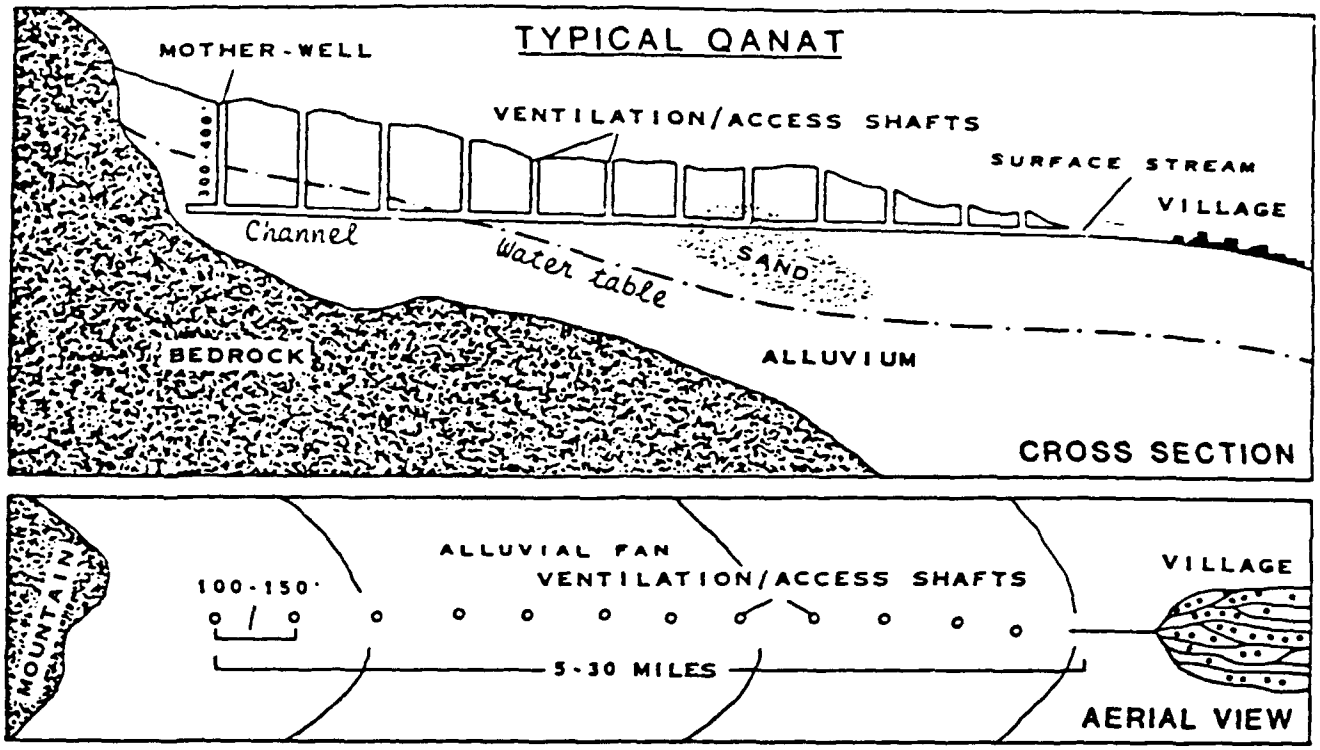


Figure 2.--Diagram of a typical qanat

3. LEGEND, TABLES AND SUPPLEMENTARY INFORMATION

The following tables and information are presented in the margins of the overlay. Appendix A presents format, explains symbols used, and gives examples of each of the following:

Legend
Potential Water-Sources Data Table
Ground-Water Potential and Characteristics Table
Definition-of-Characteristics Table
Water-Quality Class Definitions Table
Abbreviations Table
Conversions Table
Supplemental Information

4. CRITERIA FOR SELECTING AND MAPPING FEATURES

The information on the overlay is compiled from topographic and geologic maps, areal and satellite photography, geological data and other indicators of ground-water potential; these include well fields, springs, irrigated agricultural areas, presence of surface water, wells and qanats, and the presence of vegetation. In addition, estimates of the quantity of ground water is made by evaluating past and present climate, drainage basin size, rock types, rock structure, and yields of existing wells.

In general, and where available, maps of surface drainage, geology, topography and land use are combined to prepare the analysis for this overlay. For example, low lying areas of sedimentary rock types, particularly unconsolidated alluvium, with surface water and land uses that require water, such as agriculture, in combination indicate an area where ground water is likely to be found. Based on the analysis of data a determination is made of the ground-water potential and characteristics.

Ground-water potential in each of the defined areas is classified, as qualified by military well-drilling operations, as G (Good), M (Marginal) P (Poor), or U (Unsuited) based on the following six criteria: yield, depth to water, aquifer thickness, water quality, aquifer materials, and overburden materials.

G (Good): A potential well in a good area would have a yield of at least 200 Lpm (53 gallons per minute), a depth-to-water less than 100 m (328 feet), an aquifer thickness of at least 10 m (33 feet), water quality that is fresh, overburden materials that are no harder than sandstone, and aquifer materials that will store and yield water as well or better than sandstone.

M (Marginal): A potential well in a marginal area would have a yield of at least 100 Lpm (26 gallons per minute), a depth-to-water less than 500 m (1640 feet), an aquifer thickness that may be less than 10 m (33 feet), water quality that must be at least brackish, overburden materials that are no harder than limestone, and aquifer materials that will store and yield water as well or better than limestone.

P (Poor): A potential well in a poor area would have a yield that is less than 100 Lpm (26 gallons per minute), a depth to water less than 500 m (1640 feet), an aquifer thickness that may be less than 10 m (33 feet), water quality that may be saline, overburden materials that may be as hard as igneous rocks, and aquifer materials that will store and yield water similar to igneous rock.

U (Unsuited): A potential well in an unsuited area would have little or no potential for yield, a depth-to-water that may be greater than 500 m (1640 feet), an aquifer thickness that may be less than 10 m (33 feet) (or there may be no aquifer and no ground water). Note that areas with difficult accessibility characteristics--steep mountainous terrain and/or swamps and bogs are all rated as U (Unsuited).

On some overlays, two areas may be given the same rating code but have important differences in ground-water potential. In these cases the rating code will be followed by a numeral, for example G1 or G2, and both codes will be displayed on the overlay and in the Ground-Water Potential and Characteristics Table.

For example on an overlay, a G1 may refer to an alluvial aquifer that has no overburden, 10 m (33 feet) depth to the aquifer, and contains fresh water that yields greater than 400 liters per minute (106 gallons per minute). On the same overlay, G2 refers a sandstone aquifer that lies at a depth of 95 m (312 feet), has a sandstone overburden, and yields fresh water of 200 liters per minute (53 gallons per minute). Both situations meet the G criteria, but there are significant differences between them in terms of aquifer type, depth to aquifer, and yield.

In many cases, more than one aquifer lies beneath the surface of a given area; only the aquifer rated most highly in terms of potential for ground water will be coded on the overlay. When two or more aquifers receive equal ratings only the shallowest--easiest to access--aquifer is shown. Information on the deeper aquifer is included in the Supplemental Information statement.

6. HOW TO USE THE OVERLAY

This overlay can help in locating existing wells, well fields, springs, and qanats, and can also be used to estimate how much and what quality of water to expect from these features. The features are plotted on the overlay using symbols explained in the legend. For most features, the only information on the overlay will be the location of the feature and whether it is permanent or intermittent, but for those features that are numbered, additional information is available in a margin table. The overlay also contains information that can help locate new wells.

The following is a step-by-step procedure for using the GROUND-WATER RESOURCES overlay to locate the best well location and to evaluate the ground-water potential of any part of the JOG:

1. Assemble the maps and overlays for the area of interest.

2. Examine the legend and become familiar with the features and symbols shown on the overlay. Locate wells, well fields, springs, and qanats on the overlay; a number next to an overlay symbol means that there is detailed information available for that feature in the table, Potential Water-Sources Data. This table can provide information on how much water the well will yield, how deep it is, what the quality is, and what the overburden and aquifer materials are.

If there are numbered wells in the area of interest, the information on well yield from the Potential Water-Sources Data Table may be used to assess how well the ground water resources from this area can meet requirements. Caution should be exercised in assessing the potential for the use of water from existing wells; in arid rural areas, ground-water resources are often fully utilized by the local population.

Wells shown on the map may be production wells or observation/test wells. Observation or test wells are most often drilled to a smaller diameter than are production wells, and hence will be difficult to use because a submersible pump may not fit into the well. These wells may provide substantial guidance in locating production wells.

3. Unless all the water needs can be met with unused water from existing wells, it will be necessary to import water and/or assess the potential for drilling new wells. Note that the overlay is divided into regions that are each identified with a G, M, P, or U, or sometimes G1, G2, M1, M2, etc. These are codes to the ground water potential in each of these regions. G means Good, M means Marginal, P means Poor, and U means Unsuited. The best potential for a well would be in a region coded with a G, second best would be M. Normally, do not consider areas rated U; these either have no water, the depth-to-water exceeds military water-drilling equipment capabilities, or the area presents access difficulty. There are two tables in the overlay margin that, when used together, will provide more information than just G, M, P, or U.

4. Examine the Ground-Water Potential and Characteristics Table; it presents each of the ground water potential codes and reading across the table, a number is shown for each of these characteristics: yield of well, depth-to-water, aquifer thickness, quality of water, overburden thickness, and aquifer thickness. These numbers are cross-referenced to the Definition-of-Characteristics Table where each number represents a category under one of the six characteristics.

For example, if the code for an area of interest is M (for Marginal); look at M in the Ground-Water Potential and Characteristics Table and note the following numbers for each of the characteristics: Yield of Well = 3, Depth to Water = 2, Aquifer Thickness = 3, Quality of Water = 2, Overburden Materials = 2, and Aquifer Material = 2. Then look these numbers up in the Definition of Characteristics Table to find the following information about this area.

Yield of Well = 3: Wells in this region will typically yield less than 200 liters per minute (53 gallons per minute).

Depth-to-Water = 2 The level of water in a typical well will be between 25 and 100 meters (82 to 328 feet) below ground surface.

Aquifer thickness = 3: The thickness of the water-bearing formation (aquifer) is typically less than 10 meters (33 feet).

Quality-of-Water = 2: Ground water from wells in this region will probably be brackish; total dissolved solids (TDS) of 1500 to 15,000 milligrams per liter (mg/L) or parts per million (ppm).

Overburden materials = 2: The overburden (materials that will have to be drilled through to reach the aquifer) will typically be equal to sandstone in terms of drilling difficulty. The material may not necessarily be "sandstone", but could be another rock with similar drilling characteristics.

Aquifer materials = 2: The aquifer material will typically be equal to sandstone in terms of hydraulic properties, i.e. how much water it stores and how easily the water is yielded to wells.

In general "Sand and Gravel" (Class 1) aquifers store a large quantity of water and can yield that water at high rates to wells. At the other extreme "Igneous" (Class 4) aquifers hold little, if any, water. Class 2 ("Sandstone") is a good aquifer, but not the best. The actual aquifer materials could be other than sandstone.

VII. APPENDIX A -- LEGENDS, TABLES, AND SUPPLEMENTARY INFORMATION

Each overlay contains a legend and several tables that contain information that serves as a key to the data presented on the overlay. Other tables serve to define abbreviations or present equations to convert metric system units to English system units. Both the SURFACE-WATER RESOURCES and the GROUND-WATER RESOURCES overlays include supplemental narrative that help to explain the information on the overlay.

1. LEGENDS

Each legend provides a key to the identification of the features or facilities shown on the overlay. *Symbology may vary on each overlay depending on when it was published. It is important to refer to the legend on the overlay for each map; legends for adjacent overlays may not use the same symbols.*

1.1. LEGEND EXAMPLE -- EXISTING WATER-SUPPLY FACILITIES overlay

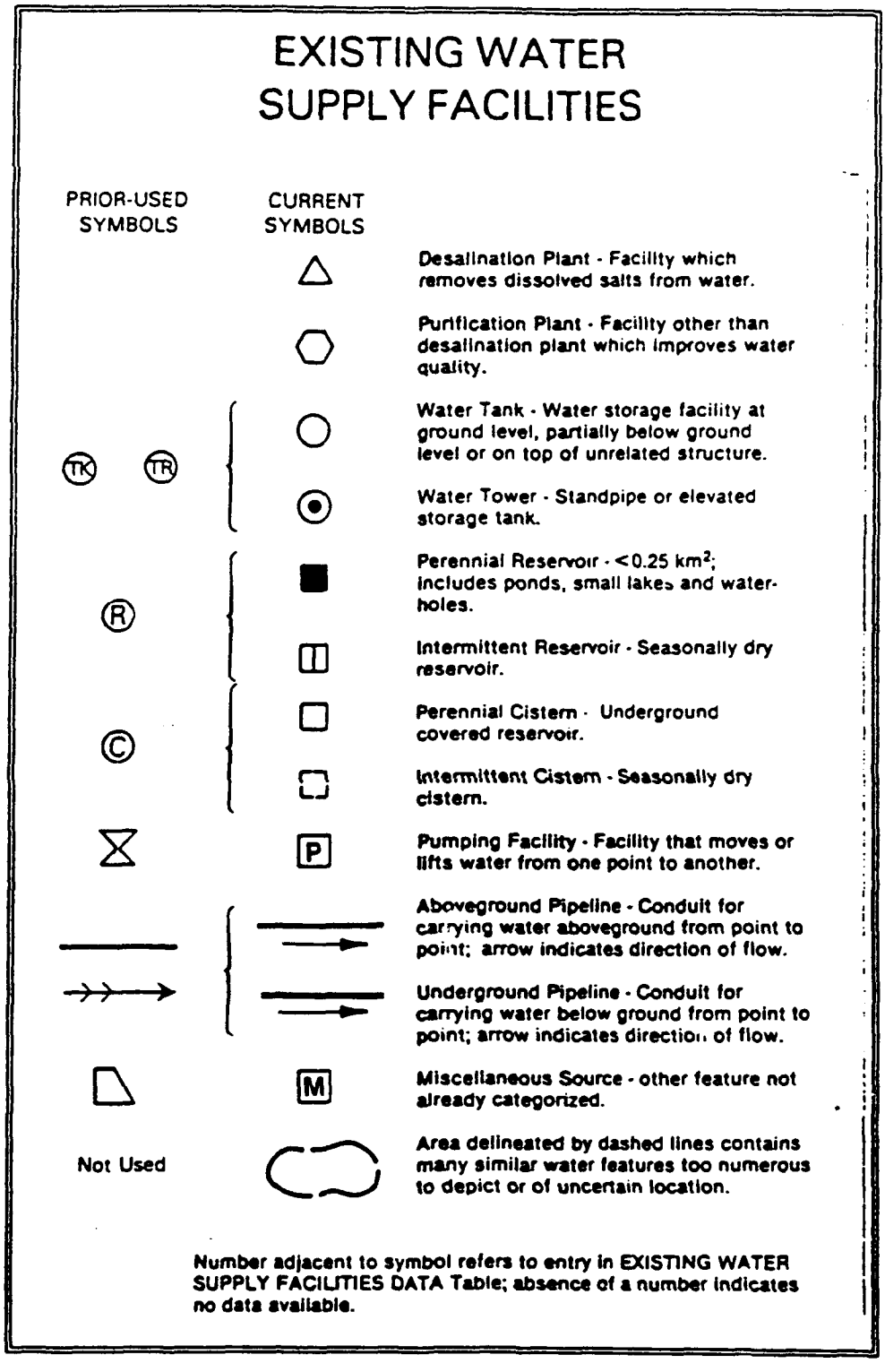


Figure 3.--Example Legend for EXISTING WATER-SUPPLY FACILITIES overlay.

1.2. LEGEND EXAMPLE -- SURFACE-WATER RESOURCES overlay

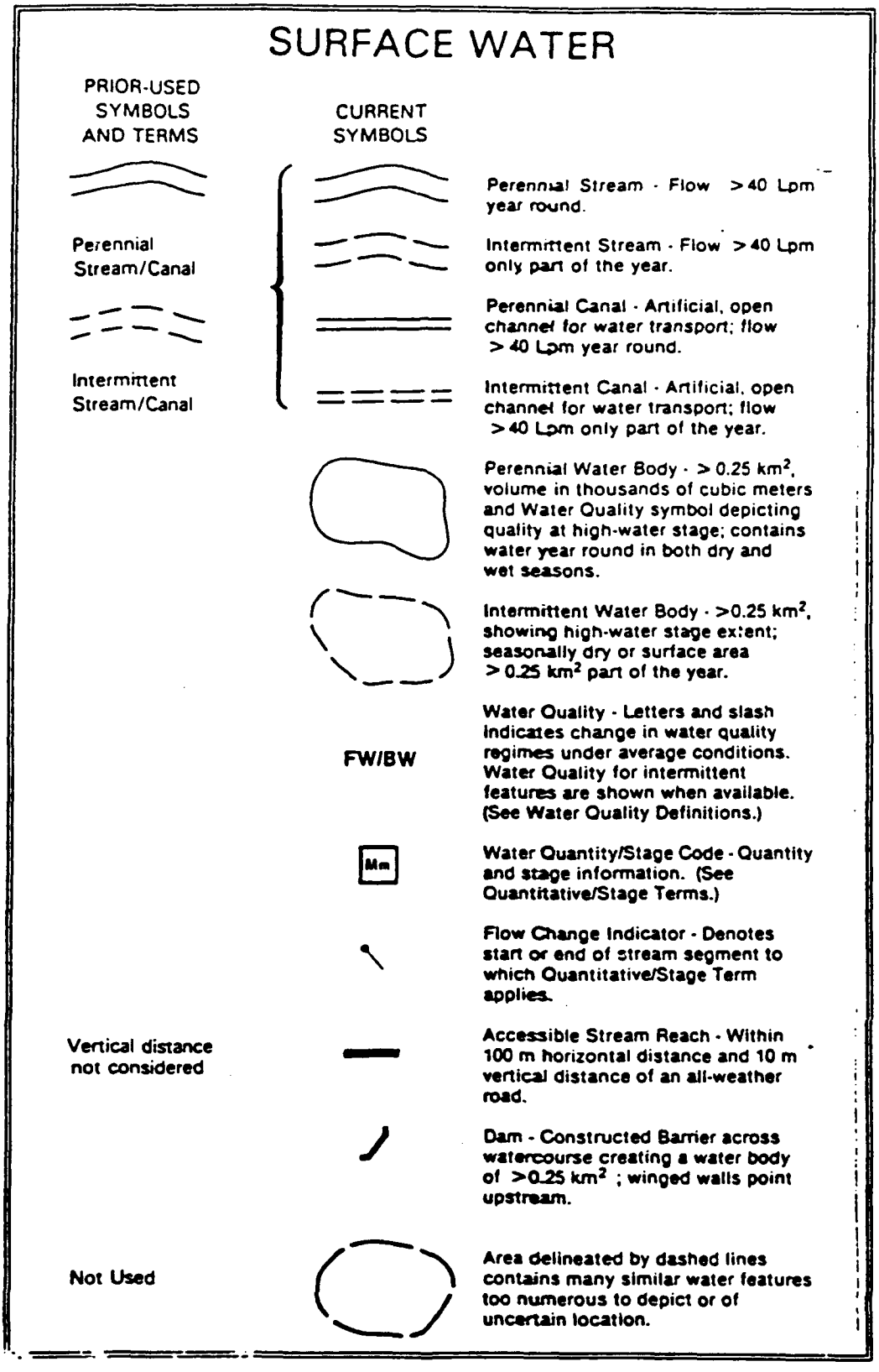


Figure 4.--Example Legend for SURFACE-WATER RESOURCES overlay.

1.3. LEGEND EXAMPLE -- GROUND-WATER RESOURCES overlay

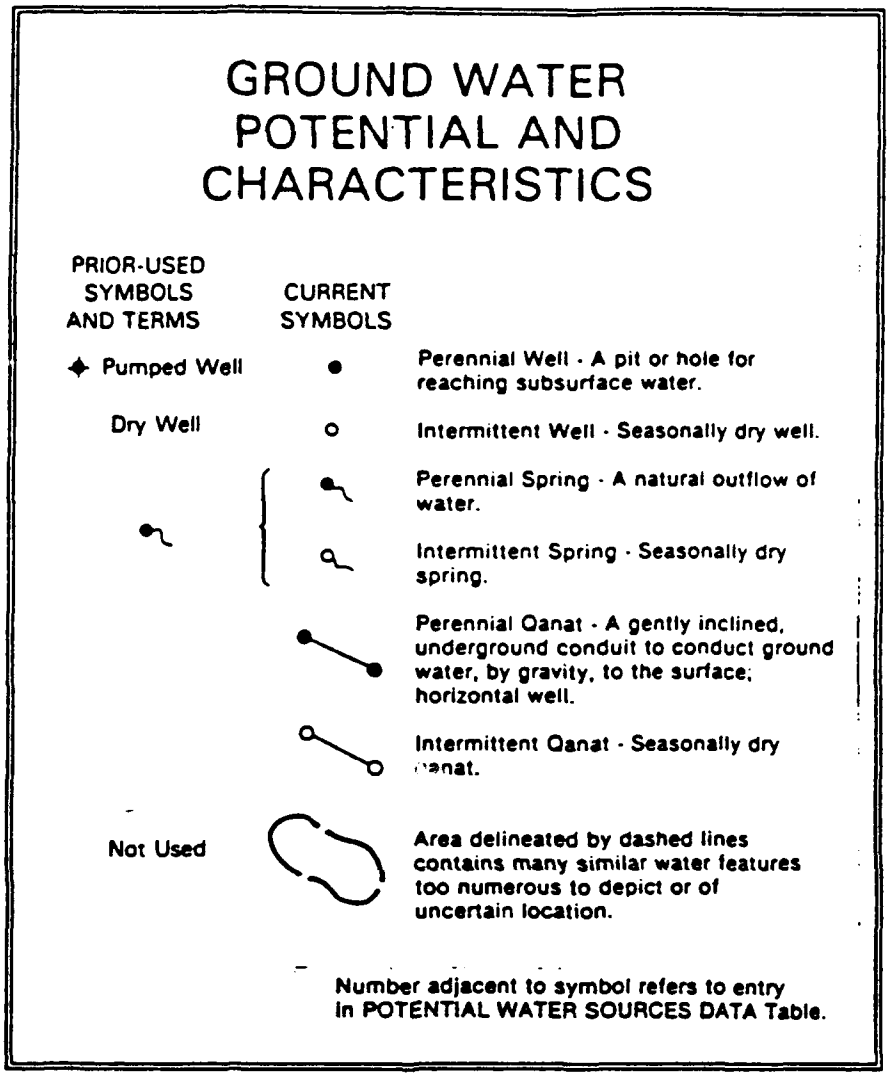


Figure 5.--Example Legend for GROUND-WATER RESOURCES overlay.

2. TABLES

2.1. EXISTING SUPPLY-FACILITIES DATA TABLE

The Existing Supply-Facilities Data Table is only on the EXISTING WATER-SUPPLY FACILITIES overlay. It provides detailed information on specific facilities. Facilities that have a number adjacent to the overlay symbol will be identified on this table and will be keyed to the number. Information, as available, is provided for these facilities as to location, type, capacity, and miscellaneous information. Note that in entry number 7, two sets of UTM coordinates are provided; these identify the original and destination locations of this feature within this overlay.

EXAMPLE: Existing Water Supply Facilities Data Table

EXISTING WATER SUPPLY FACILITIES DATA TABLE

NUMBER	UTM GRID COORDINATE	TYPE OF FACILITY	ESTIMATED CAPACITY	REMARKS
1	UD34604922	Four Water Tanks	6,490 m^3	Total Capacity
2	UD384983	Water Tower	600 m^3	Within Military Reservation
3	UD44104112	Pumping Station	100 m^3/hr	
4	UD384883	Desalination Plant	Unknown	1 unit, multistage flash, oil fired, seawater feed.
5	UD321491	Swimming Pool	Unknown	
6	UD5547658675	Water Tank	Unknown	Under construction
7	UD34587654 UD44678656	Underground Pipeline	Unknown	Carries fresh water; 30 cm diameter
8	UD333423	Oasis	Unknown	
9	UD354987	Water Tower	3,234 m^3	Actual capacity
10	UD543785	Five Water Tanks	890 m^3	Capacity of one tank.

Figure 6.--Example of Existing Water Supply Facilities Data Table.

2.2. POTENTIAL WATER-SOURCES DATA TABLE

The Potential Water-Sources Data Table is only on the GROUND-WATER RESOURCES overlay. It can provide information on the yield and quality of water from ground-water features that are numbered. Information on depth to water or aquifer, overburden and aquifer material, water use, and other miscellaneous information may also be shown. This example shows a representative sampling of types of data that may appear in the table. Note that in entry number 2, two sets of UTM coordinates are provided; these identify the original and destination locations of this feature within this overlay.

EXAMPLE: Potential Water-Sources Data Table

POTENTIAL WATER-SOURCES DATA TABLE

Number	Type of Feature	UTM Grid Coordinate	Yield (Lpm)	Water Quality (TDS)	Remarks
1	Well	UD123456	200	fresh	Depth to water 30 m; overburden limestone; sand & gravel aquifer.
2	Qanat	UD44302168 UD56342534	50	1,150	Water supply for village; sulfate 250 mg/L
3	Spring	UD350890	5	Brackish	Yield varies from 50 Lpm in wet season to 3 Lpm in dry season.
4	Well-field	UD364986	2,500	1,100	Ali Amar Wellfield; 15 wells with total yield greater than 2,500 Lpm.
5	Two wells	UD43989870	157	Unknown	Well depth 38m; yield applies to one well only.

Figure 7.--Example of Potential Water-Sources Data Table.

2.3. GROUND-WATER POTENTIAL AND CHARACTERISTICS TABLE

The Ground-Water Potential and Characteristics Table provides a key to the potential of regions for drilling wells and the development of ground water.

EXAMPLE: Ground-Water Potential and Characteristics Table

(U) GROUND WATER POTENTIAL AND CHARACTERISTICS

POTENTIAL	CHARACTERISTICS					
	Yield of Well	Depth to Aquifer	Aquifer Thickness	Water Quality	Overburden Materials	Aquifer Materials
GOOD						
G	1	2	1	1	1	1
MARGINAL						
M1	2	2	2	2	1	1
M2	2	3	1	2	3	2
M3	2	3	1	2	3	3
POOR						
P1	4	2	2	1	1	1
P2	3	2	1	3	3	3
P3	1	1	1	3	1	1
UNSUITED U	Little or no Potential for Ground Water Supplies.					

Numbers relate to specific classes defined in the DEFINITION OF CHARACTERISTICS Table.

Figure 8.--Example of Ground-Water Potential and Characteristics Table.

Areas on the overlay will show potential as G (Good), M (Marginal), P (Poor), or U (Unsuited), but this table, when used in conjunction with the Definition-of-Characteristics Table, will define the ground water potential in terms of yield, depth to aquifer, aquifer thickness, water quality, overburden materials, and aquifer materials. This table shows a numerical value for each of the characteristics for each potential; these numbers are defined in the Definition-of-Characteristics Table. On some overlays, each potential may be further subdivided, i.e. G1, G2.

To use this table, find the potential code for the area of interest, look up this code in the Ground-Water Potential and Characteristics Table, and then using the numbers in the table for that potential, look up the aquifer characteristics in the Definition-of-Characteristics Table.

2.4. DEFINITION-OF-CHARACTERISTICS TABLE

The Definition-of-Characteristics Table provides classification criteria for each of the well characteristics and when used in conjunction with the Ground-Water Potential and Characteristics Table, detailed information on ground-water potential can be obtained.

EXAMPLE: Definition-of-Characteristics Table

DEFINITION OF CHARACTERISTICS

CHARACTERISTICS	CLASSES 1	2	3	4
Yield of Well	> 400 Lpm	200-400 Lpm	100-200 Lpm	< 100 Lpm
Depth to Aquifer	< 25 m	25-100 m	100-500 m	> 500 m
Aquifer Thickness	> 50 m	10-50 m	< 10 m	
Water Quality	FRESH	BRACKISH	SALINE	
Overburden Materials	Unconsoli-dated	Sandstone	Limestone	Igneous
Aquifer Materials	Sand & Gravel	Sandstone	Limestone	Igneous

Figure 9.--Example of Definition-of-Characteristics Table.

This table shows the range of values (four classes) expected in each of the defined characteristics:

Yield of Well: This indicates how much water to expect from wells drilled in this region. For example, the class " > 400 Lpm" means that wells will typically have a yield that is greater than 400 liters per minute or greater than 106 gallons per minute.

Depth to Aquifer: This indicates how deep the rock formation is that contains the water. For example, the class "25-100 m" means that for wells in this region, the typical depth from the ground surface to the water-bearing formation (aquifer) is between 25 and 100 meters or 82 to 328 feet. On some overlays produced before 1985, this category was entitled "Depth-to-Water", where the depths indicated are the depth one would have to drill in order to reach water in the aquifer.

Aquifer Thickness: This indicates how thick the aquifer (water-bearing formation) is. For example, the class, " < 10 m" means that the aquifer in this area is typically less than 10 meters or 33 feet thick.

Water Quality: This indicates what water quality to expect from wells in this region. The Water-Quality Class Definitions Table defines the three classes of water quality: Fresh, Brackish, and Saline.

Overburden Materials: This indicates what "type" of material the overburden is made of. The rock types reported are to be considered only as representative of the hardness of the actual rock. In this class, "sandstone" means that the overburden will be no harder to drill through than sandstone. A higher number means the drilling will be more difficult.

Aquifer Materials: This indicates what "type" of material the aquifer is made of. The rock types reported are to be considered only as representative of the hydraulic properties of the aquifer. The "sand and gravel" aquifer (1) is the most likely to contain abundant relatively shallow ground water. The "igneous" aquifer (4) is a hard rock with little, if any, water. The properties of the "sandstone" (2) and "limestone" (3) aquifers lie between these extremes. A true limestone aquifer may contain abundant water, particularly in areas where solution of the limestone by ground water has produced large cavities producing terrain known as Karst.

2.5. WATER-QUALITY CLASS DEFINITIONS TABLE

The Water-Quality Class Definitions Table presents the criteria for water quality classifications. This table is common to all overlays, but on the SURFACE-WATER RESOURCES overlay is sometimes called the Qualitative Terms Table. Water is defined, based on standards set forth in the Army publication TB MED 577, as either Fresh, Brackish, or Saline based on the criteria in the table.

EXAMPLE: Water-Quality Class Definitions Table

WATER QUALITY CLASS DEFINITIONS

FRESH WATER	Maximum chlorides	600 mg/L
	Maximum sulphates	400 mg/L
	Maximum TDS	1,500 mg/L
BRACKISH WATER	TDS	1,500 mg/L to 15,000 mg/L
	Alkalinity and salinity range from very high to very low.	
SALINE WATER	TDS	> 15,000 mg/L

Figure 10.--Example of Water-Quality Class Definitions Table.

In the BRACKISH WATER and the SALINE WATER categories, the only consideration is TDS; TDS is a measure of how much material is dissolved in the water; the higher the TDS, the lower the water quality.

2.6. QUANTITATIVE/STAGE TERMS TABLE

The Quantitative/Stage Terms Table presents a key to the symbols used to denote the amount of water to be expected in stream and canal reaches.

EXAMPLE: Quantitative/Stage Terms Table

QUANTITATIVE TERMS (Stream code)

(1st Letter) Quantity	Liters Per Minute (Lpm)	(2nd Letter) Water Stage
L - Large	>4000	h - high
M - Moderate	400-4000	m - mean (most frequently occurring condition)
S - Small	40-400	l - low

EXAMPLE [Mm] Represents moderate quantity at mean water stage

\ denotes start or end of stream segment to which a stream code applies

Figure 11.--Example of Quantitative/Stage Terms Table.

2.7. ABBREVIATIONS TABLE

An Abbreviations Table is included on most overlays; it provides a reference to units and other abbreviations used on the overlay.

EXAMPLE: Abbreviations Table

ABBREVIATIONS

cm .....centimeter	cm^3 .....cubic centimeter
gal.....gallon	gph.....gallons per hour
km.....kilometer	L .....liter
Lpm.....liters per minute	m .....meter
m^3.....cubic meter	m^3/d .....cubic meters per day
m^3/hr ...cubic meters per hour	mg/L .....milligrams per liter
sec .....second	U/C .....under construction
TDS.....total dissolved solids	

Figure 12.--Example of Abbreviations Table.

2.8. CONVERSIONS TABLE

A Conversions Table is included on most overlays; it provides conversion equations from metric to English system for units used on the overlay.

EXAMPLE: Conversions Table

CONVERSIONS

1,000 L = $1m^3$ 1 Lpm = 16.7 cm^3/sec = 15.9 gph 1 gal = 3.785L

Figure 13.--Example of Conversions Table.

3. SUPPLEMENTARY INFORMATION STATEMENTS

3.1. STREAM CHARACTERISTICS STATEMENT

The Streams Characteristics Statement is a narrative statement that provides information on the availability of surface water resources. It is a brief overview of the flow characteristics of the rivers and streams on the overlay, and generally gives an indication of which are the best water sources and where the best accessibility is. It presents information on the rainfall distribution (wet and dry seasons), and may also contain specific information related to the tables or text in the overlay margin or to information displayed on the overlay itself.
EXAMPLE: Stream Characteristics Statement

(U) STREAM CHARACTERISTICS

All streams on this overlay are intermittent. Some streams may not flow each year due to low precipitation which is often localized, unpredictable, and of short duration. Average annual precipitation is less than 10 cm and usually occurs between December and March. Flash flood conditions are common and sustained flow is generally a few days in length.

The best sources of water on this overlay are Wadi Abdulla (ND123456) and Nad'i ad Berabgha (NE321231). When rainfall occurs, these streams flow for a longer period of time than the other streams on this overlay. Access to Wadi Abdulla and Nad'i ad Berabgha is easy because they are flanked by broad, flat alluvial plains of sand and gravel.

Intermittent canals only contain water during and immediately following rainfall. Access to the canals is easy due to the adjacent flat, cultivated fields.

Accessibility to the streams on the remainder of this overlay is difficult due to rugged terrain.

Numerous intermittent lakes provide Fresh to Brackish water on a seasonal basis. Water is expected to remain in these lakes for several weeks following rainfall. Accessibility is difficult due to unstable soil conditions.

Biological contamination of the streams, canals, and lakes can be expected near populated areas.

Figure 14.--Example of stream characteristics statement.

3.2. GROUND-WATER RESOURCES SUPPLEMENTAL INFORMATION

This Supplemental Information statement contains information on ground water resources. It is a brief overview of the ground-water conditions, and may contain specific information related to one or more of the tables, or information displayed within the overlay itself.

EXAMPLE: Supplemental Information (Ground-Water Overlay)

(U) SUPPLEMENTAL INFORMATION

The southeastern corner and southern edge of the overlay are dominated by the moderately to highly dissected northern slopes of the Jabal Jabala mountains. The remainder of the overlay consists of thick alluvial deposits of the Af Sifraha Plain which gently slopes from the Jabal Jabala to the Mediterranean Sea. The alluvium is underlain by limestones which rest upon sandstones at greater depths.

The areas classified as G are located in sandy aquifers at depths of 20 to 45 m. Wells usually yield 400 to 2,500 Lpm. Water is fresh with TDS content of less than 1,400 mg/L. Near the coast, precautionary measures must be taken during pumping to prevent salt-water intrusion.

The M1 areas are located in the Abu Shaybuh sandstones which are overlain by limestones. Wells are expected to yield 300 to 600 Lpm of fresh water. Depth to aquifer is between 100 to 300 m.

The areas designated as M2 are also located in the Abu Shaybuh sandstones but are overlain by gypsum. Wells are expected to yield 300 to 600 Lpm of brackish water with depth to aquifer ranging from 300 to 500 m.

The P area is located in the sandstones of the Kiklaha Formation. Wells are expected to yield 100 to 1,000 Lpm of fresh water with depth to aquifer ranging from 50 to 250 m. This area is overlain by dense non-water-bearing basalt flows that are resistant to drilling.

Figure 15.--Example of Ground-Water Supplemental Information Statement.

VIII. APPENDIX B -- UNITS DEFINITIONS AND CONVERSIONS

1. DEFINITIONS

a. Flow and Volume

Feature Type	Unit of Measure	
Desalination facility, output	m^3/d	cubic meters per day
Purification facility, output	m^3/d	cubic meters per day
Pipeline capacity, flow	m^3/hr	cubic meters per hour
Pumping capacity, flow	m^3/hr	cubic meters per hour
Storage Tank and Tower, capacity	m^3	cubic meters
Reservoir and Cistern, capacity	m^3	cubic meters
Surface Water Bodies, volume	m^3	cubic meters
Stream and Canal, flow	Lpm	liters per minute
Spring, flow	Lpm	liters per minute
Qanat, flow	Lpm	liters per minute
Well and Well field, yield	Lpm	liters per minute
Pipeline, diameter	cm	centimeters

b. Measurements

Area	Km^2	square kilometers
Distance	Km	kilometers
Size and height	m	meters
Temperature	°C	degrees Celsius (to convert to Fahrenheit, multiply by 9/5, and add 32)
Precipitation, depth	cm	centimeters

2. EXPANDED METRIC-ENGLISH UNITS CONVERSIONS

centimeter	0.39 inches
meter	39.37 inches
kilometer	0.62 miles
	3,281 feet
square kilometer	1,000,000 square meters
	0.3861 square miles
liter	1.057 quarts
	0.26 gallons
1 liter per minute	0.26 gallons per minute
	15.9 gallons per hour
	16.7 cm^3 (cubic centimeters) per second
cubic meter	264.2 gallons
cubic meters per hour	15,852 gallons
cubic meters per day	380,448 gallons